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From Health Decisions to Performance: The Network Effect

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ABSTRACT

This study uses a simulation as a vehicle for social networks research application. Eighty five companies were created as part of a simulated healthcare industry. Our results suggest that companies positioning themselves at pivotal points within the network outperform companies that do not. The findings show the applicability of network theory and the use of simulations in applied research on healthcare decision-making.

Keywords

Social Networks, Decision-Making, Performance.

INTRODUCTION

One of the key questions in strategy research is where a company should position itself within its industry (e.g., see Gulati et al., 2000). This question has been given extra impetus in the healthcare industry by increasing pressures on healthcare organizations to achieve efficiency and contain costs (Lombardi, 2005). Our main hypothesis is that company performance in the healthcare industry can be more fully understood by examining the company's relationships and ties within the network in which it is embedded instead of just focusing on the company as an autonomous entity. Such a network encompasses the company's set of relationships with other companies in the industry, e.g., suppliers, distributors, customers, and competitors.

One way to deepen understanding and examine the network effect is to investigate this area using simulations. Simulations are considered important motivational and learning tools (Garris et al., 2002), a link between abstract concepts and real-world problems, a "learning by doing" or "hands-on" approach (Martin, 2000; Kolodner et al., 2003). We use a simulation as the means by which to establish a realistic environment for laboratory research on networks. We also use the simulation to foster a heightened awareness of network attributes in order to gain insights regarding healthcare companies conduct and performance. We simulated a healthcare industry to examine how company behavior in this industry impacts its performance.

Our investigation begins with a section reviewing recent network literature and simulation studies. Then, we introduce the study's hypotheses and present the study's methodology. Next, we present the results and analyze the hypotheses. Finally, we discuss the applicability of this study and propose some future research directions.

LITERATURE REVIEW

Network Theory

Increasing interest in networks research in the past decade has resulted in an exponential growth of studies across several disciplines in this area, including healthcare (see Borgatti and Foster 2003, Christakis and Fowler, 2009 and Valente, 2010 for a comprehensive literature review). Network theory is an interdisciplinary field that searches for a common formalism for networks found in real-life. The goal of network theory research is to gain a greater understanding of the structure and flow patterns within networks.

Networks exist in all aspects of life (see Newman, 2003 and references therein). Some illustrations are as follows: (a) social networks are sets of people with interaction patterns between them; (b) citation networks and the World Wide Web (WWW) are examples of information networks; (c) technological networks are man-made networks designed typically for the distribution of commodities or resources, such as the electrical power grid and the Internet; and (d) biological networks, where substrates and products are connected with metabolic processes between them.

Each network consists of basic atomic units, called *vertices* (e.g., people, web pages, power plants or substrates) and means by which they are connected, called *edges* (e.g., relationships, hyperlinks, power lines or metabolic processes). The number of edges a vertex holds is called the vertex's degree.

In this study we focus on the practical aspect of networks and measure their influence on company performance. Particularly, we look at the healthcare industry and examine how those companies behave. In general, networks can operate on different levels and the relationships between the actors play an important role in how problems are modeled and solved. An extensive literature review of networks research (and its application in a social context) may be found in Carrington et al. (2005), Freeman (2004) and Wasserman and Faust (1994). There is also a growing body of research that is coming to terms with the economic consequences of companies participating in social or strategic networks (e.g., Ben-Zvi, 2009; Gulati, 1999; Gulati et al., 2000). This underlines the importance of understanding network theory, and highlights the need for focusing research on this area. We address this notion using the platform offered by simulations.

Simulations and Research

A simulation is, by definition, a highly complex man-made environment. The objective of using simulations in the management arena (including healthcare management) is to offer participants the opportunity to experiment by doing in as authentic a management situation as possible and to engage them in a simulated experience of the real world (e.g., Garris et al., 2002; Martin, 2000).

The area of simulations in the management arena is extensively covered in literature. Over the years, researchers have reported the extent of usage of simulations in both academe and industry (e.g., Asakawa and Gilbert, 2003; Dasgupta, 2003; Eldredge and Watson, 1996; Haapasalo and Hyvonen, 2001; Swartout and van Lent, 2003; Tomlinson and Masuhara, 2000). Information Systems literature also suggests the application of simulations as a learning tool (see, Ben-Zvi, 2010; Draijer and Schenk, 2004; Léger, 2006; Nulden and Scheepers, 2001).

Overall, simulations in the management arena provide participants the opportunity to take on the roles and responsibilities of executives, to become deeply involved in decisions faced by real people in real organizations, to feel the pressure and to recognize and to assume the risks. Moreover, this method is an excellent tool to test the understanding of theory, to connect theory with application, and to develop theoretical insights in a laboratory environment. The participants are provided the opportunity to develop some useful practical skills and to practice the tools, techniques and theories they have acquired over time. This enhances the characteristics of simulations as a mirror to real-life situations and the observed participant behavior may be generalized to reality (e.g., Lainema and Makkonen, 2003).

HYPOTHESES

In this study, we focus on the practical aspect of networks and examine how company collaboration in the healthcare industry impacts performance. Numerous studies examined the structure of networks and the characteristics of their vertices from different perspectives (e.g., Borgatti and Foster 2003; Carrington et al., 2005; Hu and Pekin, 2010); however, the way through which the network characteristics affect performance is still largely unknown.

Studies investigating the economic consequences of social or strategic networks show that companies enter alliances to improve their competitive position (e.g., Burt, 1992; Gulati et al., 2000; Goerzen, 2005; Xi and Yuan, 2010). It seems clear that if healthcare is to become more cost effective, better strategies for disseminating information and diffusing innovations through communities using social influence processes need to be devised (West et al., 1999). In addition, healthcare social networks have been used before to yield meaningful measures of social integration, and to investigate the social dynamics underlying community function and population health (Christakis and Fowler, 2007, 2009; Valente, 2010). In this study we examine how healthcare companies profit from collaboration. Therefore, we hypothesize:

Hypothesis H1: Companies collaborating with other companies outperform companies that do not.

Moreover, previous studies showed that the larger the number of collaborators, the better the state of a company (see, for example, Ben-Zvi and Gordon, 2007; Cool and Schendel, 1988; Smith and Goldman, 2009; Ye and Kasemsarn, 2010).

Therefore, the second hypothesis examines the relationship between the number of collaborators and company performance, as follows:

Hypothesis H2: The larger the number of a company's collaborators, the better its performance.

Studies show that the lack of strong links between groups or individuals generates holes in the structure of the network (Greve and Salaff, 2003; Burt et al., 2001). These structural holes create a competitive advantage for those who span them (Burt, 1992). Structural holes are also related to network resilience. Network resilience is defined as a network's ability to function, or continue its flow from one vertex to another, after some vertices and their connections are removed (Newman, 2003). The existence of strong links within the network strengthens its resilience. Structural holes do the exact opposite, as network resiliency becomes dependent on a few vertices that span those holes.

Researchers confirm a positive correlation between profits and entities spanning over structural holes (e.g., Burt et al., 2002; Reagans and Zuckerman, 2001; Yasuda, 1996). Therefore, we hypothesize:

Hypothesis H3: Companies having the biggest impact on network resilience outperform the average company.

METHODOLOGY

The Simulation Employed

In order to gain significant insights from applying network theory concepts using a simulation, the simulation must fulfill three fundamental requirements: First, it must hold numerous basic atomic units, or vertices, that interact between themselves. Second, this interaction should be properly defined and measurable. Third, each vertex must have a properly defined performance measure.

We used a simulation developed in the United States, commonly known as the International Operations Simulation - INTOPIA B2B (http://www.intopiainc.com), hereafter INTOPIA™. The simulation is designed to yield substantial payoffs in practical training. It involves the participants in the executive process, motivates their need for decision-making aids and forces them to adopt a managerial viewpoint.

The simulation is highly realistic, meant to simulate the total environment. Participants immerse themselves in an artificially created world where each company can operate several branches. As we simulated a healthcare industry, "operate" can be perceived as a broad concept that may cover one or any combination of the production, marketing, distributing, exporting, importing, financing and licensing functions in the healthcare industry. Incoming participants take part in six or more simulated periods. The task of the companies is to make decisions which will guide operations (simulated by a relatively easy computer interface) in the current period and which will affect operations in subsequent periods.

Decisions were made once a week and were e-mailed to the simulation administrator to be fed to the computer program. After the program ran the data, it generated company outputs that included financial reports (e.g., a balance sheet, an income statement), production reports and market researches. These outputs were then e-mailed to the companies and are used for their decision making in sequential periods. Dozens of decisions, covering the entire range of a typical healthcare enterprise, were required of a company in each simulated period. Each company assumed one or more of the following company roles: innovative research and development (R&D) company, developing different patents, healthcare manufacturer, healthcare distributor and wholesaler. The decision-making process was based on an analysis of the company's history as presented to the participants at the beginning of the simulation, interaction with other companies and the constraints stated in the simulation (e.g., procedures for production, types of marketing channels available). The performance of a company in each period was affected by its past decisions and performance, the current decisions, simulated customer behavior, and the competition – the other companies in the industry.

Participants and Procedures

This study was conducted in a university accredited by the Association to Advance Collegiate Schools of Business (AACSB). The participants were senior MBA candidates. We conducted eight (independent) runs of the simulation, each with different participants. Table 1 details the number of simulated healthcare companies created in each run.

At the beginning of each run, the students were asked to form competing teams. The formation of the teams and allocation of executive roles within teams proceeded without any external intervention or manipulation, and were reported to the instructors before the simulation itself began. Our experience shows that executive roles are usually allocated according to the participants' expertise in certain functional areas (e.g., accountants and bankers are usually assigned the role of chief financial officers). In each run, we recorded the decisions made by all the teams. We also kept track of the teams' performance. For this research, we aggregated all the results and statistically analyzed them, as presented later.

FINDINGS

Network Analysis

This study proposes analyzing the INTOPIA simulation as a network, with all of the associated implications being acknowledged. In Table 1 we detail the number of companies the students operated in each run. As can be observed, the number of companies in the industry varied from 16 to 20 companies, with an average of 17 companies.

Semester	Run I	Run II	Run III	Run IV	Run V
No. of Companies	20	17	16	16	16

Table 1. The number of companies in each run.

We consider INTOPIA as another kind of an information network, where each company serves as a vertex and its relations or interactions with other companies (licensing, inter-company sales, etc.) are considered as edges. Figure 1 illustrates the network structure at the end of Run I. The industry was made of 20 companies. Figure 1 demonstrates the complexity of the network structure in the simulation. Note that in that particular example, 19 companies had a least one collaborator (company 11, for example, had 5 collaborators). One company, company 18, did not collaborate with any other company.

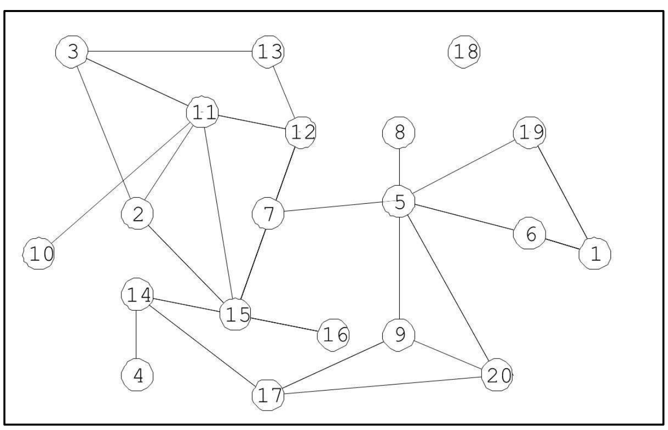

Figure 1. Network structure at the end of Run I. The industry consists of 20 companies and exhibits a complex network structure.

Table 2 presents the average number of edges of each company in each run and the standard deviation. On average, in all eight runs, each company had 2.51 edges on average with a standard deviation of 1.39. The correlation between the number of companies and the number of edges is 0.48, indicating that the larger the number of companies participating in the simulation, the larger the number of interactions between them.

Semester	Run I	Run II	Run III	Run IV	Run V
No. of Companies	20	17	16	16	16
No. of Edges per Company	2.70	2.59	2.56	2.63	2.06
Standard Deviation	1.63	1.42	1.31	1.36	1.24

Table 2. The number of edges per company in each semester.

Network Resilience

The concept of network resilience reveals the following characteristics of a network: (1) company dependency on other companies; (2) the notion of centered or pivot companies; and (3) ineffectual or weak companies. The removal or collapse of centered or pivot companies may lead to a network breakdown, whereas the collapse of ineffectual or weak companies does not significantly affect the flow of information or goods within the network. Network resilience is a measure of the number of centered companies within the simulated network. For example, in Run I, the (artificial) removal of only two companies (companies 5 and 15) results in a large dysfunction of the network, as shown in Figure 2: the large component of 19 companies breaks up to 5 smaller ones. On the other hand, a removal of a company placed on the edge of the large component, connected to only few other companies (for example, company 10, which is connected to only one company), would have little effect on the "flow" of information and goods within the network, as this company serves as an insignificant satellite of the large component.

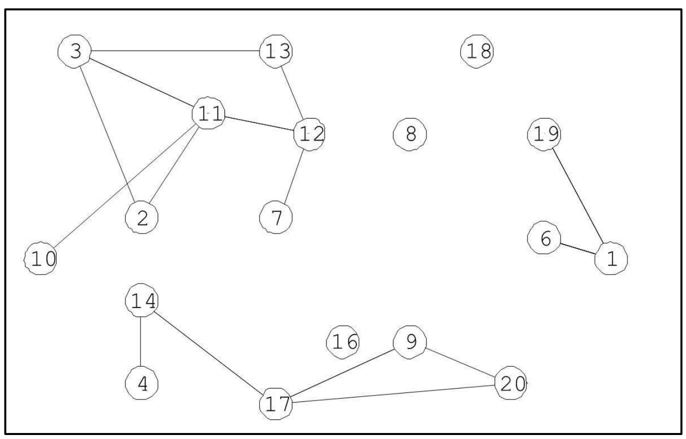

Figure 2. The network structure of Figure 1 after the (artificial) removal of two companies (companies 5 and 15).

INVESTIGATING THE HYPOTHESES – PERFORMANCE ANALYSIS

This section examines the research hypotheses and tests company performance versus network characteristics. In all runs, company performance was measured by its accumulated retained earnings (i.e., the accumulated profits). For example, Table 3 exhibits the performance of companies Run IV in absolute values and in percentage, relative to the average company in that run. The average company in Run IV achieved accumulated retained earnings of about 3.1 million dollars. Company 6, for example, achieved accumulated retained earnings of more than 10 million dollars, which is 238% more than the average company in that run. Note that companies that achieved negative profits may present performance worse than -100%. To avoid biases, we do not measure company performance in absolute values, but in percentage, relative to the average company of the associated run. For example, the performance of company 6, described above, would be 238 (which represents 238% more than the average company), while the performance of company 9 would be -59. We emphasize that the results in this section are aggregated for all five runs.

Corporation No.	Performance in Absolute Values (in K$)	Performance (in %) Relative to the Average Company
1	1,267	-59
2	(456)	-115
3	1,358	-57
4	6,248	100
5	(2,354)	-175
6	10,564	238
7	562	-82
8	(3,214)	-203
9	1,267	-59
10	16,234	419
11	(235)	-108
12	23	-99
13	(5,248)	-268
14	3,624	16
15	7,562	142
16	12,834	310
Average	3,127	0

Table 3. Performance in absolute values and in percentage relative to the average company in Run IV.

In all runs, 85% or more of all companies collaborated with at least one other company. Table 4 shows the average performance of the collaborating companies and the 'independent' companies (those companies that decided not to collaborate) in each run, relative to the average company.

Run	Run I	Run II	Run III	Run IV	Run V
% of collaborating companies	95	88	94	94	87
Performance of collaborating companies	2.24	1.20	2.11	3.93	2.93
Performance of single companies	-42.68	-8.98	-31.68	-59.00	-20.54

Table 4. Company performance – Hypothesis H1.

The results reveal that companies that did not participate in alliances with other companies usually had below-average results. We cannot determine that all results are significant due to the relatively small number of companies. We also note that some of the collaborating companies performed much worse than the 'independent' companies in the same run, but overall, on average, collaboration prevailed.

Previously, we assumed connectivity by the number of edges. Figure 3 exhibits the relationship between the number of collaborators the companies maintained and their performance, relative to the average company of all runs. The number of collaborators ranged from zero and seven. As can be seen, the larger the number of collaborators, the better the performance of the company (with R^2=0.7798). While this result can be explained by several factors, it is mainly ascribed to the reduction of risk when increasing the number of business partners, leading to a greater competition among them and, thus, an increase in the negotiation power of the company.

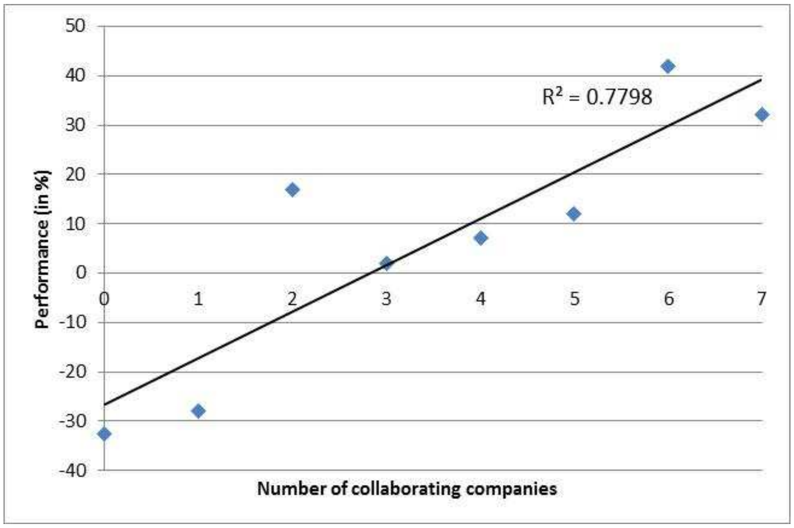

Figure 3. Correlation between Company Performance and the Number of its Collaborators.

In the previous section, we showed that by removing companies from the network, the large component, consists of most companies, may break up into smaller components. Using a computer program, we analyzed the performance of the companies whose (artificial) removal would result in the greatest fragmentation of the network. The findings reveal that when only one company was removed, it outperformed the average company by 82.8%. When two companies were targeted, those companies outperformed the average company by 52.2%. Those results were statistically significant. The findings show that companies positioned at the heart of the connection between network components were those that benefited most and outperformed the average company. They simply exploited their centrality and significance to their own benefit and thus enhanced their performance.

DISCUSSION AND CONCLUSIONS

This research used network theory concepts to better understand how healthcare companies should position themselves within the healthcare network. For that, simulated companies were formed. Although the general environment was mutual to all participants, the companies became differentiated: each assumed considerably a different strategy, different operating decisions, and a different approach to collaboration with other companies. Leaving the decision on network strategy to the groups resulted in a variety of behaviors toward other companies in the industry: fully integrated companies that conducted all the activities along the supply chain themselves, wholesalers that developed dependency in manufacturers, innovating companies that sold their R&D products, etc. It appears that these companies reflect most real-life business approaches.

Beyond the creation of simulated companies and industries, this study tested three hypotheses relating network characteristics and company performance. They were all confirmed. These results agree with those of previous similar field studies (e.g., Goerzen, 2005; Zaheer and Zaheer, 1999). Furthermore, our findings complement and extend traditional strategy and social frameworks and perspectives. They shed light on our main question of where a healthcare company should position itself with regard to other companies in the industry. The answer is complex and has two main aspects: (a) work with numerous business partners in a large component; or (b) position the company in the junction between two components. Combining these aspects, we come to the following answer: "position the company at the pivotal point of the network."

Nevertheless, although simulations today present sufficient complexity to provide realistic network features and characteristics, no simulation can seize all aspects of real-life networks. As more data from real organizations become available, it will be easier to determine the extent to which simulation situations resemble reality. Therefore, the applicability of the simulation findings to the real-world must be examined with caution. Also, there is a need to determine how simulations can be applied in studying various aspects of networks. For example, we showed that generally, performance is improved with the number of collaborators. This begs the question of why this phenomenon is not so frequently found in real life. A deeper investigation may provide important insights to better comprehend these collaboration relationships and address the notion that some companies succeed in coalescing into collaborative components while others suffer from conflict.

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